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(54) SMOKE FILTER FOR INTERNAL COMBUSTION ENGINE WITH SUPPLEMENTAL HEATING

(71) We, TEXACO DEVELOPMENT CORPORATION, a Corporation organised and existing under the laws of the State of Delaware, United States of America, of 135 East 42nd Street, New York, New York 10017, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

In conjunction with the operation of most internal combustion engines there are provided a variety of exhaust gas treating apparatuses or means. These devices by and large embody the purpose of protecting the atmosphere and the environment by treating the exhaust gas in such a manner to remove harmful components.

Such exhaust gas treating devices generally include a unit wherein the hot exhaust gases are received. The harmful components are therein filtered, oxidized, or eliminated through chemical reaction. Thus, as the treated exhaust gas leaves the filter it is relatively harmless, free of solid particles such as carbon which have been burned off, and can be safely discharged into the atmosphere.

Usually, exhaust gas filters, or smoke filters, as they are referred to, are so positioned with respect to the engine to receive the exhaust gas in as hot a condition as possible. Thus, although the flow path of the exhaust gas becomes heated, the temperature is not always sufficiently high to be effective in burning off carbon particles. This is found to be particularly true when the engine is operated for extended periods at idle or low load conditions.

In the instance of a filter which embodies a catalytic material, the hot exhaust stream is further increased in temperature within the catalyst bed passages. However, said temperature may still be too low to combust the carbon particles which are restrained in the bed.

In the regular operation of an exhaust gas treating unit, usually while the engine is idling the filter element will be at a low temperature and of little effect except to retain solid materials from the exhaust stream. However, upon being started up the engine will soon discharge a relatively hot exhaust gas stream which, within a short period of time, can reach a temperature of about 700° or 800° at the discharge point. To be effective however in burning off carbon particles carried on the exhaust gas stream, the carbon particles should be brought to a temperature of at least 900° to 1200°F.

A further detriment experienced in the use of smoke filters designed for automotive applications is the increasing back pressure encountered over a period of time within the filter. After a period, such a circumstance can be created as a result of the accumulation of carbon particles which tend to restrict and clog flow passages. The overall effect is to plug the filter and consequently decrease the engine's efficiency.

An object of the invention is to provide exhaust gas treatment apparatus wherein the above disadvantages are mitigated.

According to the present invention there is provided apparatus for treating an exhaust gas stream carrying carbon particles discharged from an engine as a result of the combustion of a hydrocarbon fuel and air mixture in the engine, said apparatus incuding:

a casing defining a flow chamber having an exhaust gas stream inlet and an outlet;

a filter disposed in said flow chamber to allow gas flow therethrough from said inlet to said outlet while retaining said carbon particles from said stream;

a heater disposed upstream of said inlet, said heater including a combustion chamber within said exhaust gas stream; and means for periodically operating said combustion chamber whereby periodically to heat said exhaust gas stream to a temperature sufficient to cause combustion of said carbon particles retained by said filter.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a general external view of a treatment apparatus according to the invention as connected into the exhaust system of an internal combustion engine; and

Figure 2 is a longitudinal section of the treatment apparatus.

Referring to the drawings, an internal combustion engine, or a diesel engine of the type to which the present filter is adapted, need be of no particular form so long as sufficient excess oxygen is present in the exhaust stream. The necessary oxygen component is usually present in diesel and stratified charge engines. For illustrating the invention, the engine is operable on a fuel-air charge which is introduced to engine cylinders by either a carburettor system or by direct fuel injection.

Referring to Figure 1, internal combustion engine 10 includes an engine block 11 embodying a plurality of reciprocally mounted pistons. Inlet manifold 12 is connected to air filter 13 or similar inlet means adapted to receive atmospheric air. An air charge is then directed to the respective combustion chambers on the intake stroke of each piston.

Each cylinder is provided with a fuel injector 14 connected to a pump 16, as well as to a source of fuel 17. The operation of said pump 16 depends on engine speed and load conditions. The amount of fuel injected into each cylinder's combustion chamber on the intake cycle is varied, while the amount of air drawn in is maintained substantially constant.

Hot exhaust gases which result from the combustion event are discharged into an exhaust manifold 18 at a temperature of about 700° to 900°F. The manifold is in turn communicated through conduit 19 to a treatment apparatus 21. As herein mentioned, the physical or spatial relationship between exhaust manifold 18 and the inlet to treatment apparatus 21, is preferably minimized. This facilitates the operation of the treatment apparatus by retaining as much heat as possible in the hot exhaust gas stream.

Under normal operation the engine charge will be varied for varying load and speed conditions. Thus, the characteristics of the resulting exhaust gas will likewise be varied particularly with respect to temperature. It will further vary in the quantity of the respective constituents which make up the exhaust gas stream.

With regard to the present arrangement, under varying engine loads, different amounts of smoke will be present in the hot exhaust gas stream, particularly in the instance of a diesel engine. This smoke consists to a large part, of minute particles of unburned carbon. These particles when carried on the gaseous stream are black and can discharge a relatively blackish smoke.

This hot, smoky exhaust stream is introduced to the inlet end of treatment apparatus 21. The stream is thereby treated by removal or retention of the carbon particles, which stream is subsequently discharged to the atmosphere through exhaust pipe 22.

Physically, and referring to Figure 2, the present treatment apparatus 21 comprises primarily an elongated casing 23 being preferably cylindrical in cross sectional configuration. The casing, however, can assume a general ellipsoidal or similar cross sectional configuration depending on the position of the treatment apparatus within, or adjacent to the vehicle frame on which it is carried.

Casing 23 is normally formed of structural sheet metal with welded seams, being capable of withstanding the high temperatures experienced during the gas treating period. Further, it must function even though subjected to external conditions such as continuous exposure to splashing water and weather conditions.

Each respective end of casing 23 is provided with a frusto conical end wall 24 and 26. The spaced apart end walls can be welded in place to the casing peripheral edges. However, any joint capable of maintaining gas tight integrity of the unit is satisfactory for establishing the casing's substantially closed interior.

To facilitate replacement of internal parts, at least one end of the casing can be provided with a removable closure. As shown, end wall 24 includes a peripheral rim 25 which corresponds to a mating rim on casing 23. The respective elements can thereby be joined with suitable bolts, clamps or the like.

The inlet end wall 24 of the casing 23 is provided with a frusto conical configuration to define a divergent passage between inlet opening conduit 27 and the casing body 23. Said end wall is so shaped, and provided with a suitable connection such as a constricted neck, to be removably connected into the automotive exhaust gas system at conduit 19.

Casing 23 opposed end wall 26 is formed much in the manner of the inlet end 24. Specifically, said end wall 26 includes a converging section which reduces the gas passage from the casing diameter to the diameter of exhaust pipe 22.

The interior of casing 23 which defines an elongated flow compartment, is provided with a filter bed 29 to form a gas pervious mass comprising a plurality of tortuous passages. Specifically one embodiment comprises a discontinuous mass of steel wool coated with a layer such as alumina. In the alternative, said flow compartment can be provided with a filling of a catalytic material such as a catalyst coated metallic fiber. The filling material is positioned transversely of said compartment and in such manner to substantially fill the latter and function as a contact medium for exhaust gas passing therethrough.

A gas stream diffuser element 31 is disposed inwardly of, and concentric with end wall 24. Said diffuser functions to direct gas across the face of filter bed 29. A gas pervious panel 32 is disposed transversely of casing 23 to define the rear wall of bed 29. Said filter bed 29 can be formed in a variety of configurations to provide the necessary particle retaining function as gas flows therethrough. In one embodiment, filter bed 29 is comprised of intermeshed, discontinuous fibers to which a catalyst material has been applied. Thus, solid carbon particles will not only be retained; their combustion will be triggered by the action of the catalytic material. End panel 32 thus physically supports bed 29 even though the latter becomes weakened through the heating process.

Forward panel 33 at the face of the filter bed 29, comprises a gas pervious support element. It functions to distribute exhaust gas across the face of bed 29, as well as to support the latter.

To heat the exhaust gas stream, or a portion thereof, the latter is passed through a controllably heated segment of the exhaust system. As shown in Figure 2, this segment is embodied in the forward end of the treatment apparatus.

Functionally, the heating segment of the unit will raise the temperature of the passing exhaust gas stream to about 900° to 1200°F. Thereafter, when said heated stream contacts the retained carbon particles, the latter will be combusted and the gas carried away on the exhaust gas stream.

As shown in Figures 1 and 2, the exhaust gas heating segment 41 is provided with a conduit 43 which is communicated with a source of a heating fluid 42 such as compressed propane. The flow of heating gas is regulated either automatically or manually by a valve mechanism 44.

Where the exhaust gas heating operation is automatic, it can be instituted by a suitable timer as to purge carbon from bed 29 at regular intervals. Alternatively the triggering means can be in the form of a back pressure detection means upstream of the filter. Further it could be located within the body of the filter 21 or within line 19 which leads up to the filter.

Carbon accumulation will progressively tend to block the passages within bed 29. As said accumulation increases, the back pressure against exhaust gas flow will increase. However, the judicious location of a suitable back pressure detector at a point upstream of bed 29 would continuously monitor the pressure. Thereafter, the detector would initiate carbon particle burn-off at a predetermined pressure level measured at a predetermined engine RPM and load.

In one embodiment of the present invention heating segment 41 is detachably engaged with the inlet of casing 23. Clamping means 46 functions to establish the gas tight integrity of the joint, and still permits replacement of the entire heating segment if required.

Internally, heating segment 41 includes the inlet conduit 27 which can be provided with an insulated inner layer 48. A mounting column 9 extends into the exhaust gas flow passage 51 and is removably positioned in place by a locking nut or similar device. The lower end of column 9 includes a deflector 52 which defines an open ended combustion chamber 53.

The latter encloses a gas nozzle 54 as well as an igniter 56. The igniter can assume the form of a sparking or glow element and is connected to a source of electric current which is actuated in conjunction with the introduction of heating gas to the combustion chamber at a predetermined engine RPM.

Alternatively, in place of an electric igniter system, the added fuel (propane) would be mixed with a portion or all the exhaust gas and then passed through a hot catalyst bed such as a ceramic monolithic automobile exhaust catalyst, to combust the fuel. The catalyst bed would be preheated by the exhaust gas to a temperature of about 500°F or higher before the fuel valve is actuated.

An ignitable gaseous mixture is introduced to combustion chamber 53 by nozzle 54. The latter is in turn communicated with the source of heating gas 42, as well as with a source of air. Air can, if necessary, be introduced in quantities to promote formation of a suitable ignitable mixture by means here represented by a conduit 58 including a valve 49.

As the heating gas is ignited in combustion chamber 53, the ensuing flame 59 will heat at least a portion of the exhaust gas stream flowing through the annular passage thereabout. The heated stream will then mix with the remaining exhaust stream, enter flow deflector 31 and be guided as a dispersed flow against the face of bed 29.

The exhaust gas stream, now heated to the ignition point of carbon, will flow through bed 29 to contact carbon whereby to combust the particles and carry off the carbon as a gas.

Introduction of the heating medium can be sustained for as long as it takes to purge or dispel accumulated carbon from bed 29. Thereafter, the flow will be discontinued, and the cooler exhaust gas flow will again pass through the filter bed 29.

WHAT WE CLAIM IS:—

1. Apparatus for treating an exhaust gas stream carrying carbon particles discharged from an engine as a result of the combustion of a hydrocarbon fuel and air mixture in the engine, said apparatus including:

a casing defining a flow chamber having an exhaust gas stream inlet and an outlet;

a filter disposed in said flow chamber to allow gas flow therethrough from said inlet to said outlet while retaining said carbon particles from said stream;

a heater disposed upstream of said inlet, said heater including a combustion chamber within said exhaust gas stream; and

means for periodically operating said combustion chamber whereby periodically to heat said exhaust gas stream to a temperature sufficient to cause combustion of said carbon particles retained by said filter.

2. Apparatus as claimed in claim 1, wherein said means for periodically operating said combustion chamber includes an ignition element disposed in said combustion chamber, and means for introducing an ignitable gaseous stream into said combustion chamber.

3. Apparatus as claimed in claim 1, wherein said means for periodically operating said combustion chamber includes a nozzle opening within said combustion chamber, said nozzle being connected to a source of an ignitable gaseous mixture.

4. Apparatus as claimed in claim 3, including a catalyst bed within said combustion chamber into which said ignitable gas mixture is directed.

5. Apparatus as claimed in claim 1, including back pressure detection means positioned upstream of said filter and adapted to initiate operation of said heater at a predetermined back pressure.

6. Apparatus for treating an exhaust gas stream carrying carbon particles discharged from an engine, said apparatus being substantially as described herein with reference to Figure 2 of the accompanying drawings.

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1598099 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

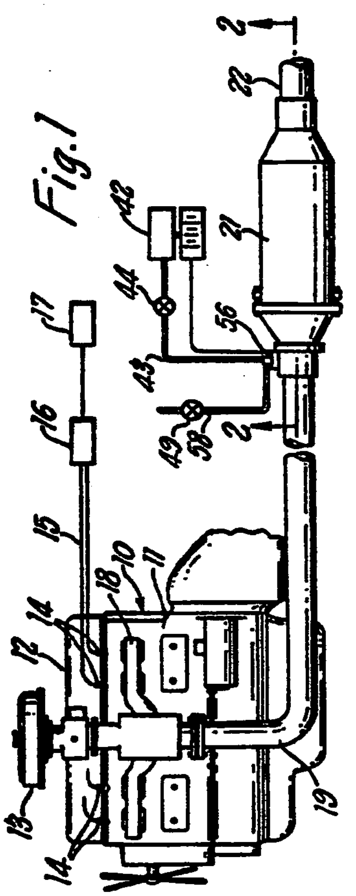
Fig. 1

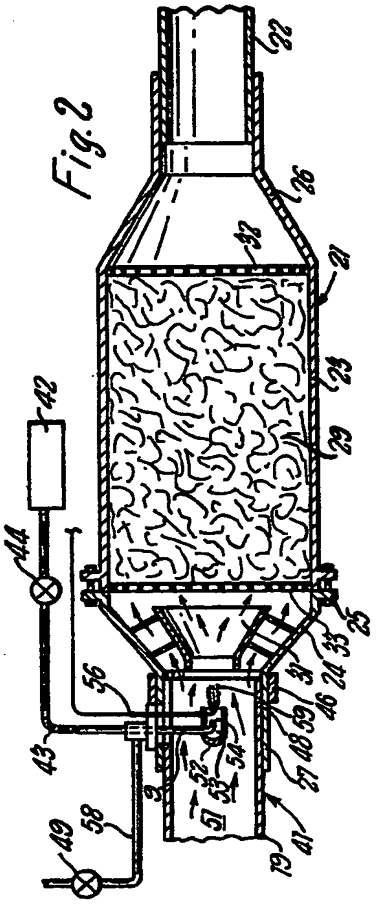
Fig. 2